WORKING DRAFT
Green and White Sturgeon
Conservation Themes with Stressors, Impact Mechanisms, and Conservation Measure Concepts

Note: Information presented in this draft table is a preliminary work in progress and will continue to be refined based on new information as it is gathered. Citations and other documentation supporting the information will be provided in or appended to the table as more specific information is developed. This table was prepared by the following individuals at two BDCP technical working sessions held on April 4, 2007 and April 11, 2007: Diane Windham and Jeff Stuart (NMFS); Scott Cantrell, Tom Schroyer, and Mike Donnellan (DFG); Zoltan Matica and Alicia Seesholtz (DWR); Rick Sitts (Metropolitan); Campbell Ingram (TNC); Josh Israel (UC Davis); Chuck Hanson (Hanson Environmental); Pete Rawlings and Rick Wilder (SAIC). To prepare the information presented in this table, technical working session participants were requested to identify known and potential stressors without regard to the relative importance of and uncertainties associated with stressor effects and to identify potential conservation measure concepts without regard to their likely effectiveness in addressing stressors or their implementation feasibility. Life stages that could be affected by a stressor are indicated by an "X" in the table and life stages that are not believed to be affected by a stressor are indicated by a "0".

HANDOUT #4
CONSERVATION THEMES AND STRESSORS

Conservation Theme	Stressor	Impact Mechanism	Life Stages				Conservation Measure Concepts
			Egg	Juvenile[1]	Subadult[2]	Adult	
1. Reduce sources of mortality							
1-1	SWP entrainment	▪ Entrainment into Clifton Court Forebay (CCF)[3] ▪ Loss through louvers	0	X	X	X[4]	▪ Install fish screens ▪ Improve louvers ▪ Real-time/Seasonal operations ▪ Increase outflow (?)[5] ▪ Relocate intake and improve screening (multiple intakes, new channel) ▪ Prevent entry of fish into CCF ▪ Improve velocity management and louver guidance ▪ Modify radial gate structure/operations ▪ Intertie between SWP and CVP, joint pumping, fill San Luis early to provide flexibility in operations, preferential diversion operations based on fish densities and losses ▪ Increase diversion capacity to improve operational flexibility ▪ Keep screens flush with channel bottom[6] ▪ Decrease exports

[1] <100 cm
[2] >100-105 cm (males); >100-135 cm (females)
[3] Predation losses for sturgeon within CCF are unknown.
[4] Green sturgeon are rare; both species can get hung up on "trash racks" at the facility
[5] Pulse flow likely would not work based on timing of downstream sturgeon migration
[6] Minimal (hang in hole at radial gate CCF)

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			Egg	Juvenile[1]	Subadult[2]	Adult	
1-1b	CVP entrainment	▪ Loss through louvers	0	X	X	X	▪ Install fish screens ▪ Real-time/seasonal operations ▪ Increase outflow ▪ Relocate intake and improve screening (multiple intakes, new channel) ▪ Rebuild or refurbish existing louver facility ▪ Intertie between SWP and CVP, joint pumping, fill San Luis early to provide flexibility in operations, preferential diversion operations based on fish densities and losses ▪ Reduce exports ▪ Maintance of screens to ensure screens are maintained flush with channel bottom
1-2	SWP/CVP salvage	▪ Collection, Handling, Transportation, Release (CHTR) mortality[7]	0	X	0	0	▪ Install fish screens ▪ Improve louver guidance ▪ Improve CHTR process ▪ Seasonal operations ▪ Relocate intake and improve screening ▪ Multiple release sites ▪ Different techniques for release (e.g., barge vs. truck)
1-3	CCF predation	▪ Predation	0	0	0	0	▪ Predator management/removal ▪ Modify Forebay[8] ▪ Remove Forebay ▪ Install fish screens ▪ Relocate intake
1-4	DWR owned diversions	▪ Loss at unscreened diversions (Twitchell)	0	?[9]	0	0	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations

[7] Directed primarily at post-release entrainment and predation mortality.

[8] For example, install screen/leaky rock levee so fish pass quickly through narrower channel to salvage facility, increase velocity to reduce residence time, forebay bypass to allow fish to be removed before water enters forebay.

[9] May be susceptible if high flows push small fish downstream

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			Egg	Juvenile[1]	Subadult[2]	Adult	
1-4b	DWR Operated Bypasses	▪ Fish stranding[10]	X[11]	X	X	X	▪ Build fish passage ▪ Regrade/engineer to improve drainage (e.g., scour pools) ▪ Recover stranded fish and move past barrier ▪ Remove low flow channel barriers (toe drain) ▪ Improve/add fish ladders/expand fish ladders, passage at Fremont Weir/Lisbon Weir/Tisdale Weir
1-4c	DWR Operated Bypasses	▪ Upstream passage barrier delays migration sufficiently to result in decreased egg and juvenile survival	0	X[12]	0	0	▪ Build fish passage ▪ Recover stranded fish and move past barrier ▪ Screen to prevent fish access[13] ▪ Remove low flow channel barriers (toe drain) ▪ Improve/add fish ladders/expand fish ladders, passage at Fremont Weir/Lisbon Weir/Tisdale Weir
1-5	USBR owned diversion (Rock Slough-CCWD uses)	▪ Loss at unscreened diversion	0	0	0	0	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations ▪ Encase Rock Slough canal
1-6	Private unscreened diversions (e.g., urban, industrial, agricultural diversions, Glenn-Colusa)	▪ Entrainment loss	X[14]	X	0	0	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations

[10] This is also a stressor and impact mechanism for splittail.
[11] May spawn in bypasses under some conditions
[12] Egg to juvenile survival—spawn in bad locations
[13] It may not be feasible to screen bypasses because of bypass width and magnitude of high flows.
[14] South of Hamilton City

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1-6b	Mirant Pittsburg and Contra Costa power plants	▪ Entrainment losses[15]	0	X[16]	?	0	▪ Retire/replace power plant units equipped with off-stream cooling ▪ Install improved fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations ▪ Reduce discharge temperatures ▪ Optimize variable speed circulating water pump drive (VSD) operations
1-7	North Bay Aqueduct	▪ Entrainment	0	?	0	0	None
1-8	Exposure to toxics	▪ Chronic and acute mortality[17, 18]	X	X	X	X	▪ Source control ▪ Point-source reduction ▪ Non-point source reduction ▪ Sediment removal/capping/avoid resuspension ▪ TMDL ▪ Increased enforcement ▪ Modify pesticide/herbicide technology (shift to less toxic methods)
1-9	Predation[19]	▪ Predation by sea lions[20] and striped bass	0	X[21]	X	X	▪ Predator management/removal ▪ Increase cover habitat ▪ Reduce ambush points ▪ Avoid future non-native introductions ▪ Modification of channel geometry (where hotspots for predation) ▪ Regulatory changes/permits for sea lion control

[15] May be indirect mortality of juveniles if they move to avoid entrainment and are preyed upon
[16] Likely only in flood years that push juvenile fish downstream
[17] Toxic effects have not been studied extensively but are assumed based on striped bass investigations
[18] We will contact Regina Linville about cause direct loss of juvenile through maternal transfer in white sturgeon (get contact from Josh Israel)
[19] Focus is on conditions that create non-natural heightened vulnerability to predation (i.e., "ambush points"; including barriers, in-channel structures, and any other physical in-channel features that attract the species, but also attract and conceal predators).
[20] Sea lions moving into Suisun--identified as likely major problem in Columbia River
[21] By other fish species

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1-10a	Propeller entrainment by cargo vessels[22]	▪ Entrainment mortality ▪ Increased vulnerability to predation ▪ Wake disturbance	0	X	X	X	▪ Increase off channel habitat ▪ Reduce vessel transit through Delta ▪ Increase channel width
1-10b	Propeller entrainment by recreational vessels	▪ Entrainment mortality ▪ Increased vulnerability to predation	0	?	X	X	▪ Public outreach/education
1-11	Legal Harvest[23] (in-basin and out-of-basin)	▪ Human take of individuals by various means	0	0	X	X	▪ Regulatory actions (e.g., zero harvest). ▪ Promote catch-release of white sturgeon ▪ Public outreach ▪ Closure of river fishery[24]
1-11b	Illegal harvest	▪ Human take of individuals by various means	0	0	X	X	▪ Increased law enforcement ▪ Seasonal fishing closures (all fishing) in spawning areas ▪ Increased fines and penalties ▪ Increased prosecution ▪ Public outreach ▪ Restructure regulations to restrict possession of sturgeon fishing gear ▪ Night-time fishing closure
1-12	Insufficient food supplies/location[25]	▪ Reduced growth/ health/starvation	0	X	0	0	▪ See Conservation theme 6
1-13	Disease	▪ Infection of wild fish	X	X	X	X	▪ Hatchery discharge disinfection ▪ Reduce elevated water temperature ▪ Limit disease transport from other areas ▪ Regulate commercial hatcheries to prevent introduction of disease

[22] This has been observed (T. Shroyer, DFG)
[23] Harvest is at a historical low
[24] Seasonal/zone closure could reduce abortion of eggs from hooked/escaped fish
[25] Food limitations have not been investigated – assumed based on general reduction in organic production

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1-14	DCC operations	▪ Delay in/rerouting of upstream migration ▪ Delay in outmigration and increased predation resulting from entrainment into the central/south Delta ▪ Juveniles may be redirected away from preferred habitat	0	?	?	?	▪ Re-operate DCC to improve migration success and survival[26]
1-15	Water temperature	▪ Direct mortality ▪ Shift in timing of spawning, emergence, etc.	X	X	0	0	▪ Modify upstream reservoirs to provide for cold water releases (multi-level temperature control device) ▪ Modify release operations ▪ Coldwater pool management in reservoirs ▪ Reestablish SRA in key locations ▪ Augment with cold groundwater flows ▪ Increase access to cold water reaches ▪ Expansion of Shasta to provide for coldwater releases ▪ Seasonal blending of releases for temperature management ▪ Reoperate RBDD to allow upstream passage to cooler water
1-16	Monitoring mortality	▪ Direct take	0	X	X	X	▪ Stop monitoring ▪ Change monitoring techniques ▪ Target monitoring to avoid redundancy ▪ Use BMPs for handling and release of fish (e.g., better gears to reduce mortality) ▪ Improve permit compliance ▪ Monitor to determine level of post-monitoring release mortality to inform techniques
1-17	Red Bluff Diversion Dam	▪ Entrainment loss ▪ Loss to turbulence ▪ Upstream passage	X	X	0	X	▪ Seasonal operations to avoid entrainment and upstream passage of spawning adults ▪ Redesign screen to effectively screen stugeon[27]

[26] No data, may not be able to pass DCC if on bottom
[27] Efficacy for sturgeon questionable

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			Egg	Juvenile[1]	Subadult[2]	Adult	
1-18	In-channel construction/levee maintenance activities and dredging	▪ Direct take	X	X	X	X	▪ Sound attenuation devices ▪ Seasonal windows ▪ Increase compliance with minimization measures ▪ Use less adverse methods to pile drive/install structures
2. Increase species production (reproduction, growth, survival)							
2-1	Insufficient food supplies/food quality (e.g., non-natives with less energy)/location	▪ Reduced growth, health, starvation ▪ Use of non-native, low nutrient food sources	0	X	X	X	See Conservation theme 6
2-2	Reduced suitable spawning habitat	▪ Insufficient spawning conditions	X	0	0	X	▪ Enhance spawning substrate availability and/or quality ▪ Increase access to spawning habitats ▪ Improve flow conditions to increase the frequency, duration, and area of spawning habitat ▪ Reduce fine sediment erosion/deposition ▪ Encourage channel meander and floodplain inundation (?)

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2-3	Reduced suitable rearing habitat	▪ Increased vulnerability to predation ▪ Increased competition ▪ Reduced DO and other water quality parameters ▪ Reduction in carrying capacity ▪ Reduced duration of rearing in highly productive flooded habitat producing food ▪ In-filling of rearing pools ▪ Spawning in low-turbidity tailwater areas	0	X	X	0	▪ Reduce channel velocity ▪ Increase floodplain habitat ▪ Levee set-backs ▪ Riparian corridor enhancement ▪ Increase inputs of large woody debris and overhead cover ▪ Reduce predator "hot spots" ▪ Increased access to spawning habitat also increases access to rearing habitat ▪ Increase access to existing habitat ▪ Reduce deposition by fines to increase macroinvertebrate production ▪ Increase intertidal flats ▪ Mimic natural hydrograph with reservoir releases to improve turbidity
2-4 (seasonal)	Reduced suitable adult habitat (upstream riverine—holding habitat)	▪ Insufficient spawning habitat ▪ False migration pathways resulting from delta configuration ▪ Insufficient holding habitat (?)	0	0	0	X	See measures for Stressor 2-2 and 1-15. ▪ Enhance spawning substrate availability and/or quality ▪ Increase access to spawning habitats ▪ Reduce fine sediment erosion/deposition ▪ Encourage channel meander ▪ Improve connectivity of floodplain to channel ▪ Modify upstream reservoirs to provide for cold water releases (multi-level temperature control device) ▪ Modify release operations[28] ▪ Coldwater pool management in reservoirs ▪ Reestablish SRA in key locations (e.g., holding pools) ▪ Increase quality and availability of adult habitat

[28] e.g., Increase flow conditions to create attraction flows in appropriate tributaries and reduce flows in false pathways (the last part is easier said than done)

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			Egg	Juvenile[1]	Subadult[2]	Adult	
2-5	Sublethal exposure to toxics[29]	▪ Increased vulnerability to disease ▪ Reduced growth rates ▪ Increased vulnerability to predation ▪ Reduced reproductive success[30]	X	X	X	X	▪ Source control of heavy metals ▪ Point-source reduction ▪ Non-point source reduction ▪ Sediment removal/capping/avoid resuspension ▪ TMDL ▪ Increased enforcement ▪ Modify pesticide/herbicide technology (shift to less toxic methods)
2-6	Competition	▪ Reduced food supplies. ▪ Increased energy expenditure ▪ Potential displacement from suitable habitat	0	?[31]	?	?	▪ Non-native species management/control ▪ Reduce/avoid future introductions ▪ Improve habitat for native riverine species ▪ Reduce habitat for non-native species ▪ Increase quality and availability of spawning and rearing habitat
2-7	Water quality problems (e.g., elevated temps)	▪ Impediment/barrier to migration ▪ Increased physiological stress ▪ Reduced health/growth	X	X	0	0	▪ Increase flushing flows ▪ Storm water pre-treatment ▪ Reduce exposure to seasonally elevated temps (see measures for 2-4) ▪ Decrease run-off from waterfowl clubs (Suisun)
2-8	Existing or New Levees	▪ Extent of floodplain habitats reduced (exclusion of fish from habitat) ▪ Lack of floodplain food sources	0	?[32]	X	X	▪ Levee set backs ▪ Improved access/habitat within flood bypasses ▪ Flood shallow islands and channel margins
2-9	Altered hydrology	Insufficient flow (reduced area and volume of habitat, passage, etc) Seasonal timing of flow inconsistent with life stage requirements	X	X	?	X	▪ Restore seasonal natural hydrology ▪ Manage instream flow releases to optimize physical habitat for each life stage (e.g., seasonal frequency and duration of floodplain inundation)
2-10	Passage (see below)						
3. Increase habitat quality and availability							

[29] Sturgeon are benthic, so they are exposed to toxics in sediments in addition to water column
[30] Selenium is problem for egg maturation/Hg
[31] Juvenile may compete with non-native clams
[32] Considering forage, juveniles probably would benefit the most

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			Egg	Juvenile[1]	Subadult[2]	Adult	
3-1	Reduced sediment input (change in volume, quality, geomorphic processes)	▪ Sedimentation of incubating eggs with fines ▪ Reduced sediment movement restricts quantity and quality of coarse materials ▪ Reduced dynamics of physical process that affect foodweb and microhabitat conditions	X	X[33]	0	0	▪ Increase range of flow variation (high highs that restore erosion processes) ▪ Reduce levee armor (in-Delta, upstream of Delta) ▪ Allow channel meander ▪ Beneficial sediment re-use ▪ Addition of coarse gravel above spawning areas
3-2	Reclamation/conversion of wetlands[34]	▪ Reduction in the surface area and volume of aquatic habitat ▪ Reduction in organic production within estuary ▪ Reduction in water quality	0	X	X	X	▪ Levee set backs ▪ Flood islands ▪ Increased treatment of wastewater/storm water ▪ Increase tidally inundated wetlands ▪ Increase bypass habitats (frequency and duration of suitable conditions, drainage to avoid stranding, etc.) ▪ Increase or improve connectivity of wetlands
3-3	Land use changes (ag/urban development)	▪ Increased wastewater discharges (baseline and stormwater flows) ▪ Increased infrastructure and hard points (impede conservation opportunities up and downstream) ▪ Loss of habitat and sediment inputs if channels are leveed/armored to protect development/ag lands	X	X	X	X	▪ Increase requirements for discharge water quality parameters that adversely affect fish and other aquatic species ▪ Pre-treatment for stormwater discharges ▪ Increased monitoring and enforcement ▪ Develop and implement guidance for appropriate urban development in floodplains ▪ Exclude development from floodplains that could be flooded under current hydrology with removal of levees ▪ Manage amount/type of industrial development ▪ Manage amount/type of agricultural development ▪ Limit the geographic area of development ▪ Identify and implement BMPs for urban uses/ag practices that affect habitat ▪ Promulgate additional restriction to channel modification and in channel construction

[33] Coarse gravel may be critical to river juvenile habitat
[34] Important since the estuary is important for juvenile rearing, and as habitat for sub-adults and adults

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			Egg	Juvenile[1]	Subadult[2]	Adult	
3-4	Reduced seasonal transport flows	▪ Reduced downstream transport and distribution of larvae and juveniles ▪ Seasonal co-occurrence of larvae, habitat, food supplies ▪ Increased water temperatures	0	X	0	0	▪ Increase seasonal flows in Delta tributaries and in-flow to Delta ▪ Increase seasonal Delta outflow ▪ Timed seasonal upstream releases to facilitate downstream larval and juvenile dispersal ▪ Timed reductions in water diversions to facilitate outflow transport
3-5	Reduced upstream attraction flows	▪ Delays or limits in upstream migration ▪ Reduced flushing flows ▪ Reduced attraction flows ▪ Creates false migration pathways	0	0	0	X	▪ Increase seasonal Delta inflow from Sacramento and/or San Joaquin Rivers ▪ Increase seasonal Delta outflow ▪ Increase variability, timing, magnitude, of flow by tributary ▪ Restrictive water diversion windows
3-6	Reduced riparian vegetation	▪ Reduced overhead and instream cover ▪ Reduced organic/energy inputs to the aquatic system ▪ Localized elevated water temperatures ▪ Increased erosion/sedimentation (see above stressor)	0	X[35]	?	?	▪ Increase food/energy production (Conservation theme 6) ▪ Riparian corridor enhancement for SRA ▪ Preserve existing riparian vegetation ▪ Maintain overhead vegetation on levees/reduce removal of vegetation ▪ Design new levees and levee maintenance to incorporate designs that permit growth and retention of SRA ▪ Provide for flows that support establishment and maintenance of native riparian vegetation ▪ Increase grasses and other vegetation within the floodplain

[35] May provide a velocity refuge

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			Egg	Juvenile[1]	Subadult[2]	Adult	
3-7	Channelized riprap levees	▪ Increased water velocities ▪ Increased displacement and flushing of eggs and young ▪ Reduced channel meander and sediment recruitment ▪ Reduced shallow water habitat ▪ Reduced cover ▪ Increased vulnerability to predation ▪ Reduced hydrologic connectivity between river and floodplain habitat	X	X	X	X	▪ Remove existing levee armoring ▪ Reduce/avoid future riprap[36] ▪ Employ bioengineering techniques for levee protection ▪ Levee setbacks/increased floodplain ▪ Recreate shallow water habitats in Delta ▪ Vegetate levees to improve velocity and cover conditions (e.g. LWD, innovative bank protection)
3-8	Expansion of non-native species (Egeria, Eichornia (water hyacinth) Corbula, etc.)[37]	▪ Reduced habitat quality and increased vulnerability to non-native predators ▪ Reduced flow velocities ▪ Reduced turbidity ▪ Reduced water quality (DO)	?[38]	X	X	X	▪ Expanded and enhanced eradication/control program ▪ Reduce/avoid future introductions ▪ Promote habitat features favoring native species (e.g., salinity fluctuation, flow and timing to manage/control invasive species - could require moving intake)
3-9	Increased water depth (channel dredging; marinas, ship channels)	▪ Increased velocity[39] ▪ Reduced photic zone[40] ▪ Reduced food abundance	0	X	X	X	▪ Reduce dredging volume ▪ Reduce dredging locations ▪ Limit size of dredging plots (?) ▪ Beneficial re-use of all dredge material for estuarine habitat ▪ Restore shallow-water habitats to offset effects

[36] However, where there is little course sediment and lots of fines, riprap would provide better habitat
[37] Some species (e.g., Corbula) may provide benefit (i.e., food)
[38] Non-native egg predators?
[39] Water accelerated thru deep channel portion of cross section
[40] Changed relative volume of zone –affects primary prod

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			Egg	Juvenile[1]	Subadult[2]	Adult	
3-10	Levee failure in the Delta (future under failed levee conditions)	▪ Increased risk of levee failure and adverse effects of entrainment onto island/delay in migration ▪ Increase vulnerability to predation ▪ Pollution plume	0	X	X	X	▪ Reduce practices leading to subsidence, which may strand fish. Need connectivity. ▪ Increase sediment accretion using dredge sediment re-use, import sediment, import agricultural waste. ▪ Increase organic production and carbon sequestration through ag/wetland management (re-build peat) ▪ Increase size ,height, and location (e.g., setbacks) of levees ▪ Increase levee maintenance ▪ Breach and flood selected islands for habitat
3-11	Increases in water temperature as result of global warming[41]	▪ Increased seasonal water temperatures ▪ Reduced area/distribution of suitable habitat	X	X	?	X[42]	▪ Restore wide belts of riparian vegetation adjacent to channels ▪ See measures proposed for Stressor 1-15
3-12	Changes in seasonal hydrology (climate change—diminishing snow pack, shift in rain cycle, more earlier, accelerated melting, erosion)	▪ Change in the seasonal timing/magnitude of migration flows[43]	X	X[44]	X	X	▪ Modify reservoir storage and release ▪ Build reservoirs for cool pool management ▪ Reservoir re-operations/conjunctive use ▪ Increase flexibility of reservoir operations ▪ See measures proposed for Stressor 1-15 ▪ Increase off stream storage capacities ▪ Maintain flows during outmigration period
3-13	Sea level raise	▪ Increased water depth and further loss of shallow-water habitat ▪ Change in flows and salinity (salinity moves upstream)	0	X?[45]	X	?	▪ Reduce rate of subsidence ▪ Promote active sediment accretion ▪ Restore habitat upstream ▪ Rebuild peat ▪ Increase levee size ▪ Flood islands

[41] May not be a stressor for sturgeon in the foreseeable future (dependent on management)
[42] Spawning may be triggered by temperature cues
[43] This change in hydrology could benefit sturgeon by more frequent high spring flows depending on storage operations
[44] Sturgeon recruitment seems to be strongly correlated to strong flow years
[45] Likely to be affected by salinity

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3-14	Barriers to passage[46]	▪ Delay in migration ▪ Loss of access to spawning and rearing habitats ▪ Stranding upstream or downstream of barriers ▪ Disorientation and increased predation ▪ Possible resorption of eggs if delayed too long	X	X	X	X	▪ Remove dams and other barriers preventing access to spawning and rearing habitats ▪ Modify barriers to improve passage ▪ Construct alternate channels to bypass barriers ▪ Collect stranded fish and transport to locations upstream or downstream of barriers ▪ Increase flow to increase flow over low barriers (includes low flow riffles) ▪ Seasonal operation of barriers
3-15	Future introduction of non-native species	▪ Increased competition for food ▪ Increased vulnerability to predation ▪ Reduced food supplies through biomass conversion and/or reduced production ▪ Reduced quality of food ▪ Changes in water quality and habitat characteristics	X	X	X	X	▪ Reduce the rate of future non-native species introductions ▪ Promote habitat favorable to natives ▪ Promote habitat unfavorable to non-natives ▪ Non-native species management and control ▪ Limit availability of non-natives (?) ▪ Stricter laws regarding the possession and transport of non-natives
4. Increase habitat diversity[47]							
4-1	Levee/reclamation	▪ Loss of access to suitable habitat ▪ Limiting habitat diversity	0	X	X	X	▪ Remove levees ▪ Levee set-back ▪ Increase floodplain ▪ Modify flow operations to provide multiple habitats over a wider range of flows ▪ Construct and operate passage facilities for upstream and downstream fish movement at control weirs ▪ Construct bypass channels around control structures for fish passage

[46] Shallow riffles hold up movement, 2 documented cases on Sacramento R. and at Shanghai Bend on Feather (T. Schroyer, DFG)
[47] (Concept is to address current uniformity of habitats/resilience)

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4-2	Levee/reclamation	▪ Loss of shallow water subtidal habitat ▪ Loss of low velocity shallow water riverine habitat	0	X	X	X	▪ Levee set-back ▪ Flood islands ▪ Design new or repaired levees to incorporate shallow water benches, riparian vegetation, and large woody debris ▪ Improve habitat conditions for fish within flood control bypasses ▪ Slope channel bottoms
4-3	Levee/reclamation	▪ Loss of floodplain inundation	0	X	X	X	▪ Levee set-back ▪ Breach channel margin levees ▪ Flood shallow islands ▪ Provide for channel meander in riverine reaches ▪ Lower floodplain surfaces within leveed reaches to allow for seasonal overbank flooding ▪ Lower or notch bypass weirs to extend period bypasses maintain water (could be done if adjustable weirs are installed to allow for extended spilling into bypasses during appropriate periods to avoid stranding issues) ▪ Limit development and other conflicting uses in the floodplain
4-4	Levee/reclamation	▪ Loss of intertidal habitat	0	X	X	X	▪ Levee set-back ▪ Breach channel margin levees ▪ Flood shallow islands ▪ Beneficial re-use of dredge material to create shallow-water and intertidal habitat ▪ Limit development

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4-5	Levee/reclamation/ land use changes	▪ Loss of riparian habitat	0	?	?	?	▪ Bioengineering for levee protection ▪ Plant riparian vegetation ▪ Avoid vegetation removal ▪ Levee set-back
4-6	Salinity control/compliance[48]	▪ Reduced salinity variability ▪ Increase in colonization of non-native species and changes in habitat/species interactions ▪ Decrease in certain salinity zones ▪ Change in food distribution[49]	0	?	?	?	▪ Remove/relax existing salinity control requirements ▪ Modify seasonal inflow for greater salinity variation ▪ Modify seasonal Delta outflow for greater salinity variation ▪ Modify diversions to allow greater salinity variation
4-7	Upstream impoundment storage and instream flow releases Flood control operations	▪ Reduced hydrologic variability, timing, and magnitude[50] ▪ Water quality and temperature modification	X	X	X	X	▪ Limit diversion quantities upstream of reservoirs to maintain reservoir release capacity ▪ Modify seasonal releases for greater hydrologic variation ▪ Modify seasonal releases for greater geomorphic variation (e.g. plunge pools that can be used for holding habitat)[51] ▪ Modify seasonal Delta outflow for greater hydrologic variation ▪ Maintain net seaward flows ▪ Increase the frequency and duration of flows that inundate floodplain areas
5. Increase species resilience							

[48] If sturgeon habitat moves upstream into narrows of the Delta, limitation of habitat availability may result
[49] Eliminating Corbula would reduce selenium issues (see theme 6)
[50] Affects environmental cues that trigger migration, life stage transitions—seasonal synchrony with environment—habitat structure – frequency and duration of floodplain inundation
[51] May not be feasible because of amount of water needed

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Conservation Theme	Stressor	Impact Mechanism	Life Stages				Conservation Measure Concepts
			Egg	Juvenile[1]	Subadult[2]	Adult	
5-1 (tied to 5-4)	Reduced population viability due to loss of genetic diversity[52] (Continued genetic loss)	▪ Small spawning population ▪ Increased seasonal and geographic isolation ▪ Reduced number of utilized spawning areas within an independent DPS (distinct population segment)[53]	X	X	X	X	▪ Increase habitat (theme 3); ▪ Increasing abundance and distribution of small populations in spawning tribs ▪ Increase food production (see theme 6) ▪ Reduce mortality (see theme 1) ▪ Increase adult survival to produce diversity among year classes produced ▪ Increase spawning windows where passage issues disrupt seasonal length of spawning period ▪ Provide for spawning in the SJR
5-2	Reduced population abundance	▪ Reduced genetic diversity ▪ Reduced population resilience and adaptability ▪ Difficulty finding mates in river	X	X	X	X	▪ Increase habitat (see theme 3) ▪ Increase food production (see theme 6) ▪ Reduce mortality (see theme 1) ▪ Increase flows during spawning period to ensure recruitment success ▪ See stressor 5-1 ▪ Maintain a wild broodstock conservation hatchery
5-3	Reduced population geographic distribution	▪ Reduced genetic diversity ▪ Reduced exposure to environmental variable at extremities of distribution ▪ Increased vulnerability to impacts ▪ Difficulty finding mates in river	X	X	X	X	▪ Expand distribution of suitable spawning habitat within the Sacramento River, San Joaquin River, and tributaries ▪ Expand distrbution of suitable rearing and foraging habitat in San Pablo Bay, Suisun Marsh ▪ Maintain a wild broodstock conservation hatchery

[52] Need to know what the minimum number of fish and distribution that needs to be maintained to maintain genetic integrity for sturgeon.
[53] This needs to be clarified

HANDOUT #4
CONSERVATION THEMES AND STRESSORS

Conservation Theme	Stressor	Impact Mechanism	Life Stages				Conservation Measure Concepts
			Egg	Juvenile[1]	Subadult[2]	Adult	
5-4 (tied to 5-1)	Reduction in independent populations	▪ Reduction in genetic diversity ▪ Increased vulnerability to impacts and environmental extremes (inbreeding depression)	X	X	X	X	▪ Expand distribution of suitable habitat (e.g., establish fish above upstream barriers) ▪ Increase survival in each age class to increase diversity in offspring cohorts
5-5	Increased habitat stability[54]	▪ Reduced adaptation ▪ Reduced genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	X	X	X	X	▪ Increase interannual variation in flows (timing, duration, magnitude) within ranges that maintain key habitat areas ▪ Incorporate others that apply from other stressors ▪ Levee setbacks
5-6	Reduced habitat diversity	▪ Reduced adaptation ▪ Reduced genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	X	X	X	X	▪ See Theme 4
5-7	Reduced frequency of extreme events that stress the system[55,56]	▪ Reduced adaptation ▪ Reduced genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	X	X	X	X	▪ Increase range of seasonal variation in Delta tributaries and in-Delta inflow, outflow, and salinity intrusion ▪ Levee setbacks
6. Increase food availability (phytoplankton, zooplankton, macroinvertebrates, forage fish, etc.)							
6-1	Reduced organic/energy input (inflow from upstream and in-delta production)	▪ Reduced riparian vegetation ▪ Levee stabilization ▪ Channelization ▪ Changes in land use ▪ Upstream storage/diversions ▪ Reduced waste water/nutrient inflow	0	X	X	X	▪ Increase upstream floodplain ▪ Levee set back ▪ Increase wetlands ▪ Point source organic loading ▪ Increase riparian diversity and density ▪ Limit dredging ▪ Limit pesticide usage ▪ Encourage fish friendly agriculture ▪ Increase channel meanders

[54] Sturgeon are insulated from historical range of perturbations because of modified hydrology below reservoirs.
[55] vulnerable to homogenization of conditions
[56] continued marginal conditions result in marginal production

HANDOUT #4
CONSERVATION THEMES AND STRESSORS

Conservation Theme	Stressor	Impact Mechanism	Life Stages				Conservation Measure Concepts
			Egg	Juvenile[1]	Subadult[2]	Adult	
6-2	Increased consumption of sturgeon food by non-native species	▪ Biomass conversion to non-native species ▪ Poor energetics (nutritional quality)	0	X	X	X	▪ Non-native species control/management ▪ Reduce rate of new introductions ▪ Increase primary and secondary production ▪ Provide habitat conditions favoring natives ▪ Provide habitat disfavoring non-native species ▪ Manage water releases to favor natives and disfavor exotics
6-3	Increased diversion of nutrients/production out of estuary	▪ Removal of organic carbon and nutrients from estuary resulting in reduced primary and secondary production	0	X	X	X	▪ Increase organic production ▪ Reduce seasonal diversions upstream, Delta agriculture, SWP/CVP exports ▪ Relocate intake
6-4	Competition	▪ Reduction in densities/abundance of native or suitable prey ▪ Poor energetics reduced fitness	0	X	X	X	▪ Non-native species control/management ▪ Reduce rate of new introductions ▪ Provide habitat conditions favoring native species (gravel, SRA, etc.) ▪ Provide habitat disfavoring non-native species ▪ Increase availability of suitable habitat
6-5	Increased channel velocities/reduced hydrologic residence time	▪ Reduced primary and secondary production Periodicity of food prey may not match needs of sturgeon energetics	0	X	X	X	▪ Reduce exports ▪ Increase channel cross-sectional area ▪ Increase channel meander ▪ Increase channel roughness ▪ Relocate intake ▪ Increase primary and secondary production
6-6	Increased water depths relative to the photic zone	▪ Reduced primary production	0	X	X	X	▪ Levee set-backs ▪ Flood islands ▪ Promote active sediment accretions ▪ Increase primary and secondary production
6-7	Change to non-native food sources	▪ Bioaccumulation of toxics by increased consumption of alternate foods that accumulate toxics ▪ Conversion of pelagic food sources to benthic sources (beneficial for adult sturgeon) ▪ Poor energetics reduced fitness(?)	0	X	X	X	▪ Operate Delta to disfavor non-native species ▪ Non-native species control/management ▪ Reduce rate of new introductions ▪ Provide habitat conditions favoring native species (gravel, SRA, etc.) ▪ Provide habitat disfavoring non-native species ▪ Increase availability of suitable habitat